Theme 5: Weather System Observation and Analysis

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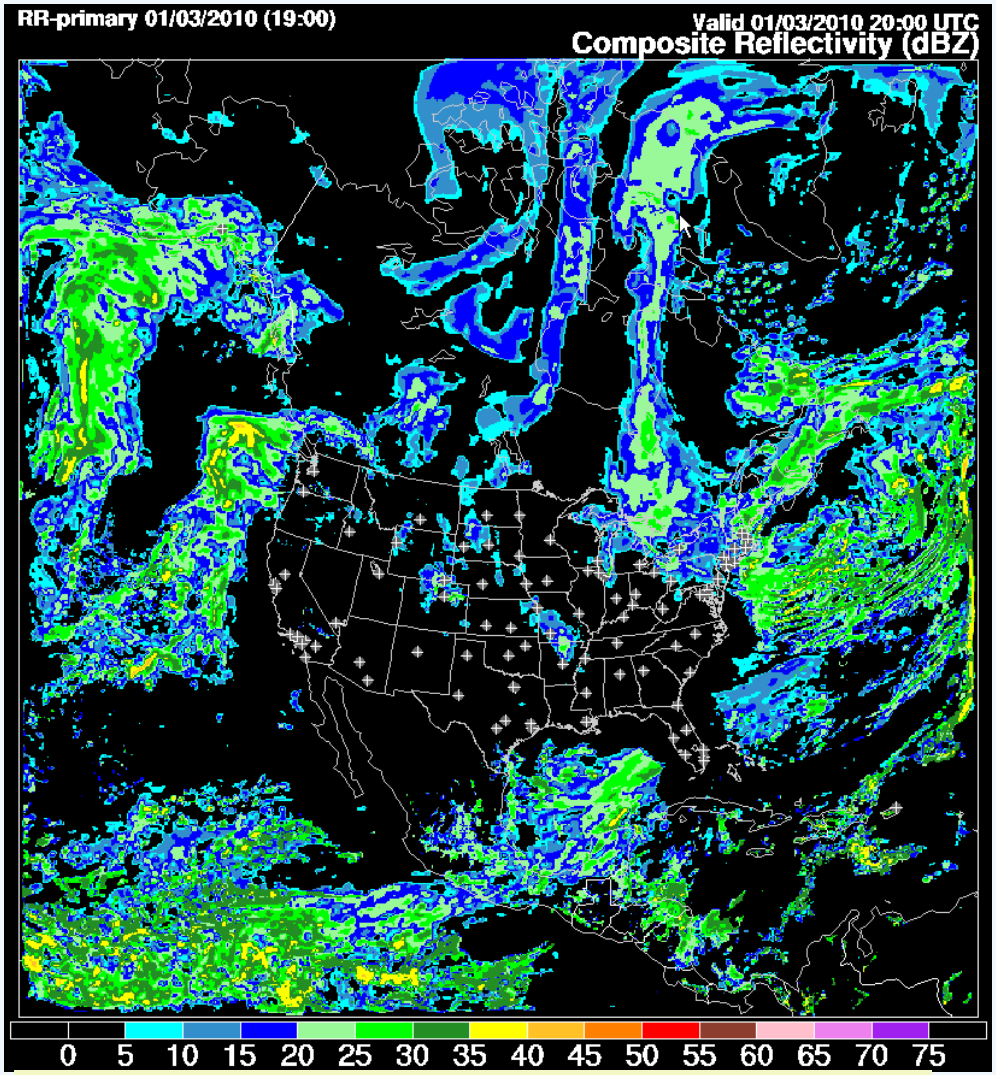
Overview

Theme 5: Weather System Observation and Analysis

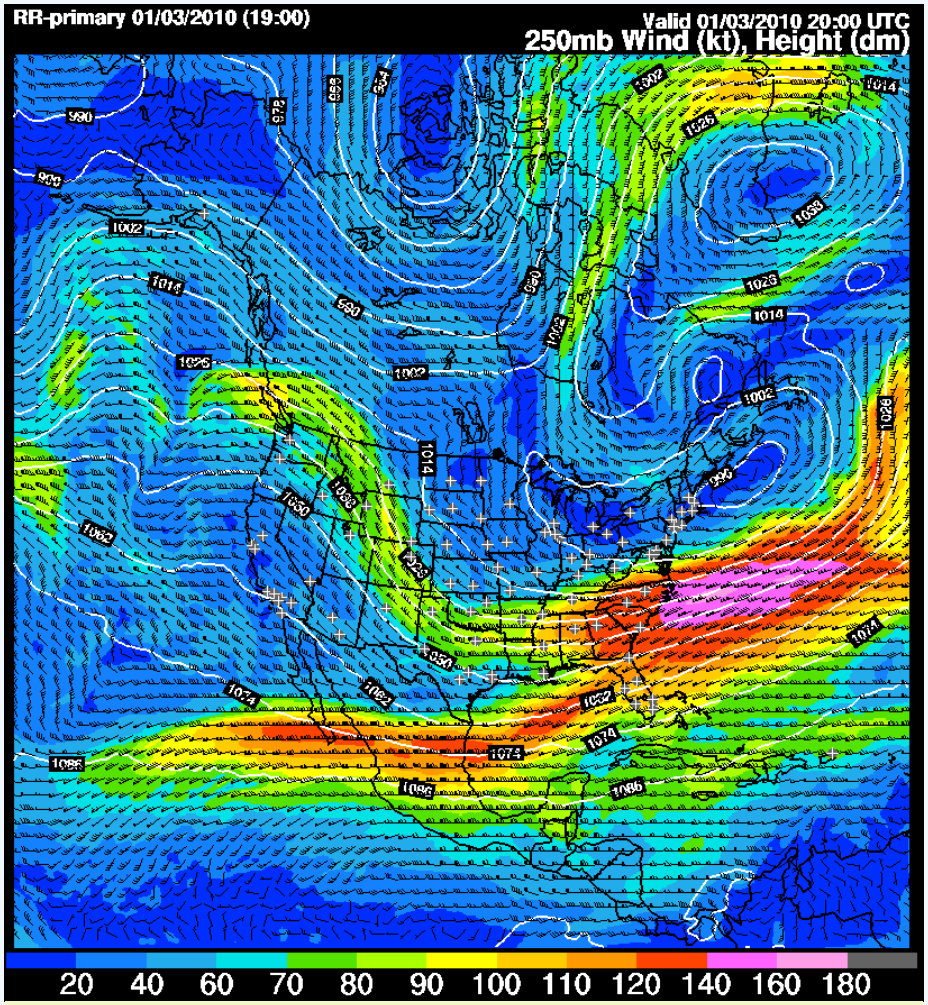
- Why Focus on Observations and Analysis?
- ESRL's unique position
- The Challenge
- Our Strategy
- Our Capabilities
- The impact of our work



Analysis from the Rapid Refresh model
Major winter storm in New England disrupts traffic

Why Focus on Observations and Analysis

- Although this is the last theme of the review,
  - **This is where it all starts**
  - We cannot fulfill NOAA's role of *understanding and predicting* our Earth System without *observing* it
  - We need to ensure the observations
    - Are correct
    - Are measuring the most relevant things
  - And, we need to develop the understanding to interpret the observations correctly

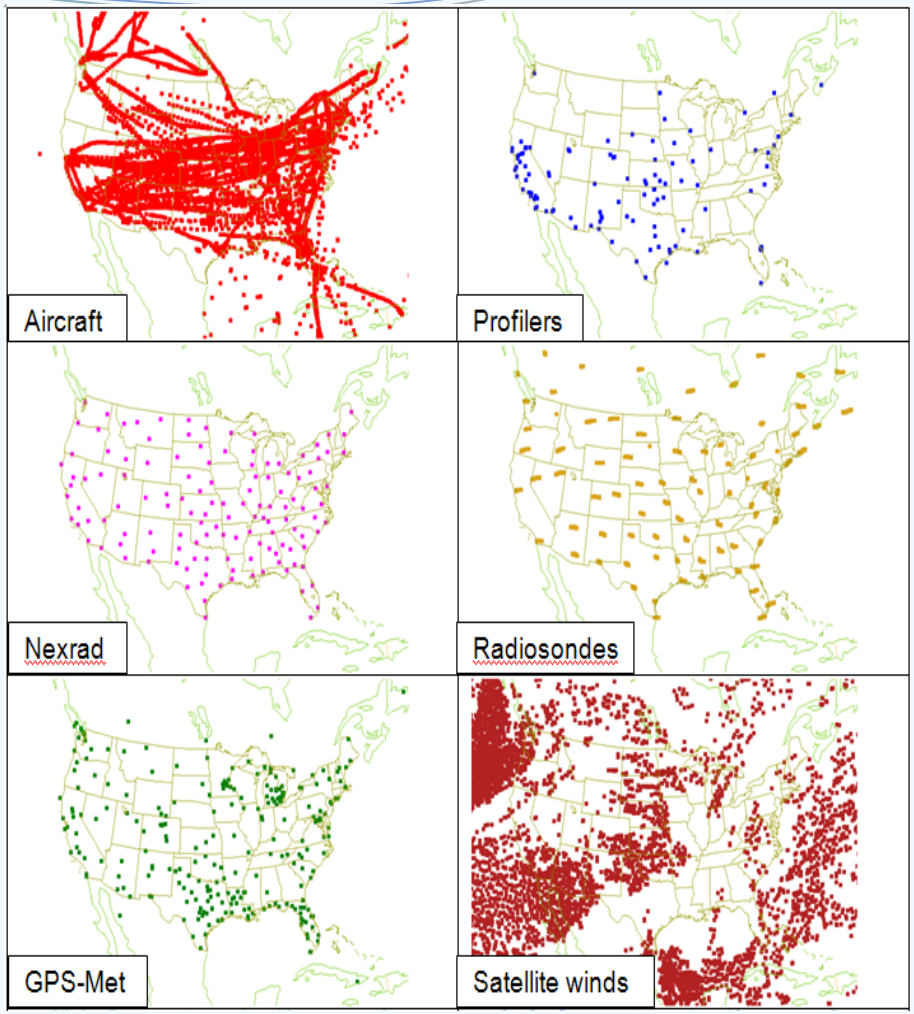


Analysis from the Rapid Refresh model
- Strong jet stream winds impact air travel

Why Focus on Observations and Analysis

- Timely information is critical for predicting rapidly-developing weather
- The government is being asked to purchase or develop new data systems
- *Are these systems a good investment?*

- This work addresses NOAA's goals of
  - "Advancing *in situ* … data collection capabilities and associated platforms and systems", and
  - "Accelerating the development of new environmental observational technology and sensors."



Some of the multiple suites of data currently available over the Contiguous United States

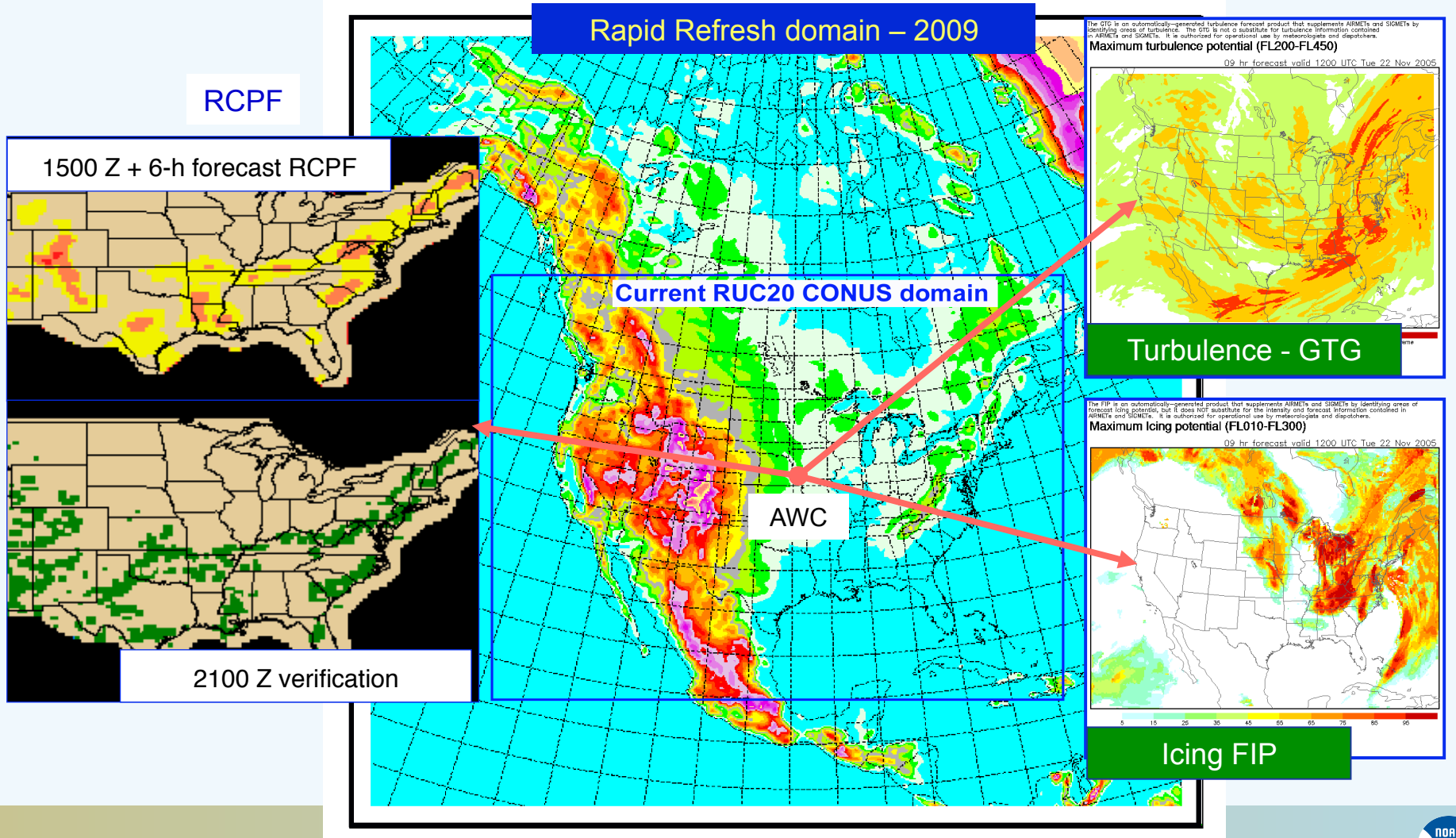
ESRL-GSD's Unique Position

- We have the flexibility of a research laboratory, without operational constraints
- *We are trusted by the operational arms of NOAA* that make procurement decisions
- We test the impact of data under *operational conditions*
- Our work builds on NOAA's unique scientific competence and resources
- Forecasts from ESRL-developed models provide critical input for life and death decisions

For example: We Provide Critical Services to Aviation

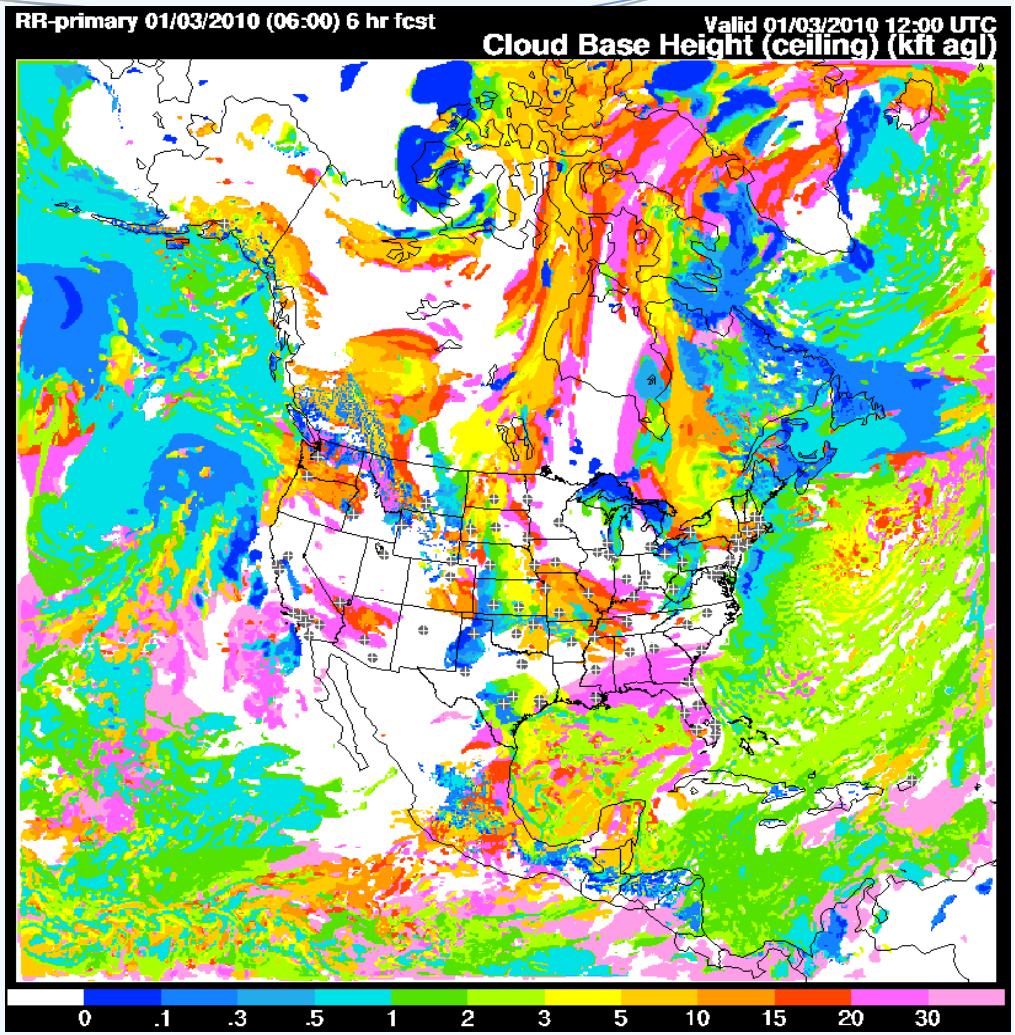
National Convective Weather Forecast (NCWF), Icing Potential (FIP), Graphical Turbulence Guidance (GTG), and the aviation weather products

All based on ESRL NWP Model Analyses and Forecasts



The Research Challenge

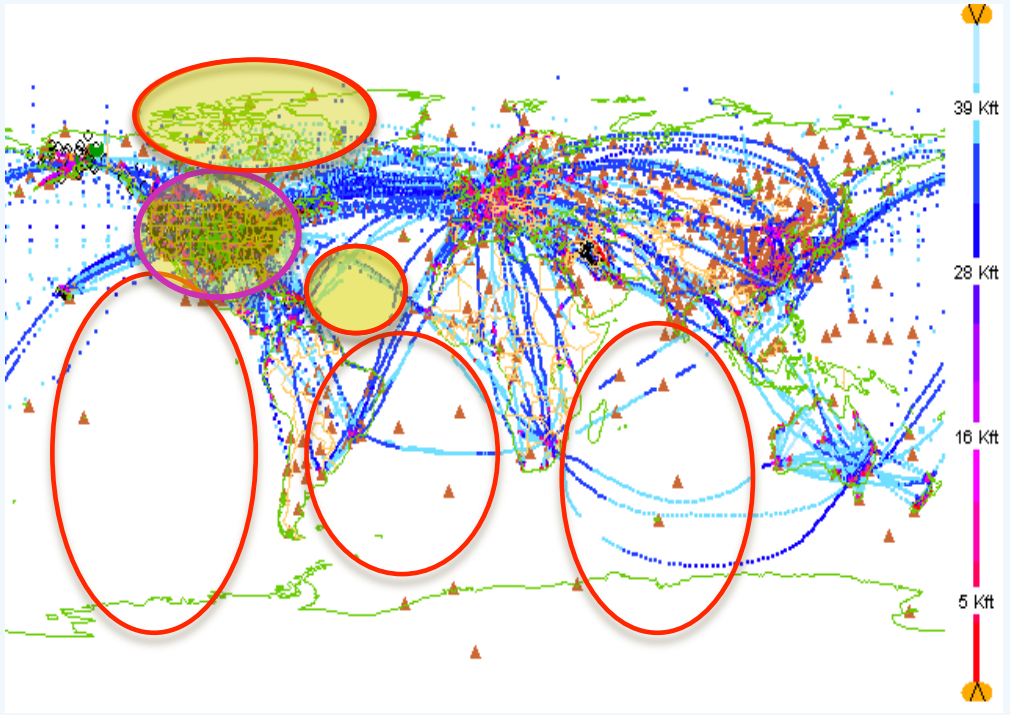
- Most forecasting is performed by *automated systems*
- Observations can *degrade* or *improve* model analyses & forecasts
- **Do the new data actually improve services to the public?**



6 hour ceiling forecast – **will you be able to land?**
(In Amarillo, maybe not—due to low ceiling)

Our Strategy

- Identify gaps
  - Find where information is missing
- Perform Observing System Experiments (OSEs)
  - For existing data systems
- Perform Observing System **Simulation** Experiments (OSSEs)
  - For proposed new data systems
- Field Studies
  - To test integrated suites of multiple data systems in a quasi-operational setting

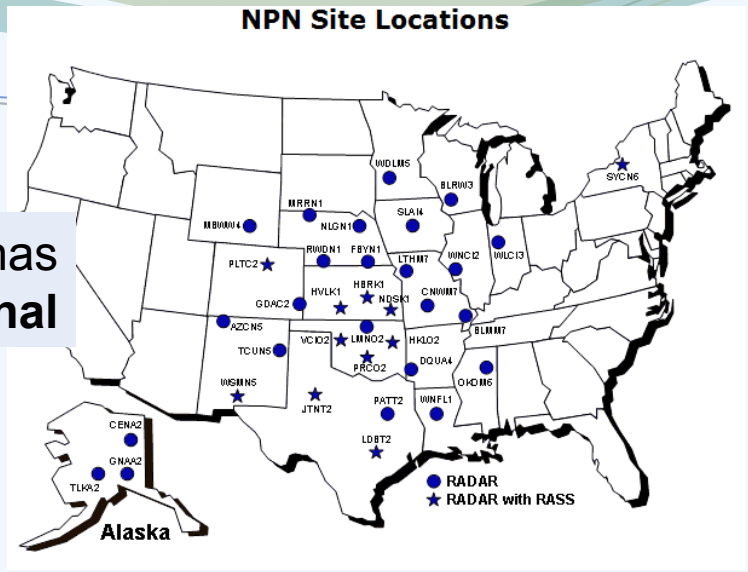


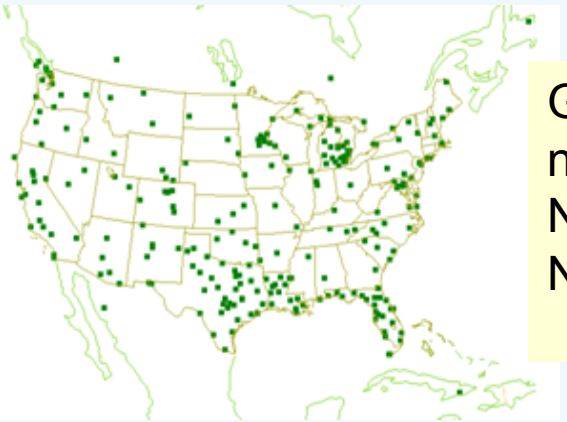
Our Capabilities

- State-of-the-art supercomputers
- Access to a wide variety of data
  - Including commercially restricted data, for which we are trusted stewards
- Deep scientific expertise
- Focus on multiple scales, from local to global
- Effective verification systems

Successes we have had

The National Profiler Network has **become operational**





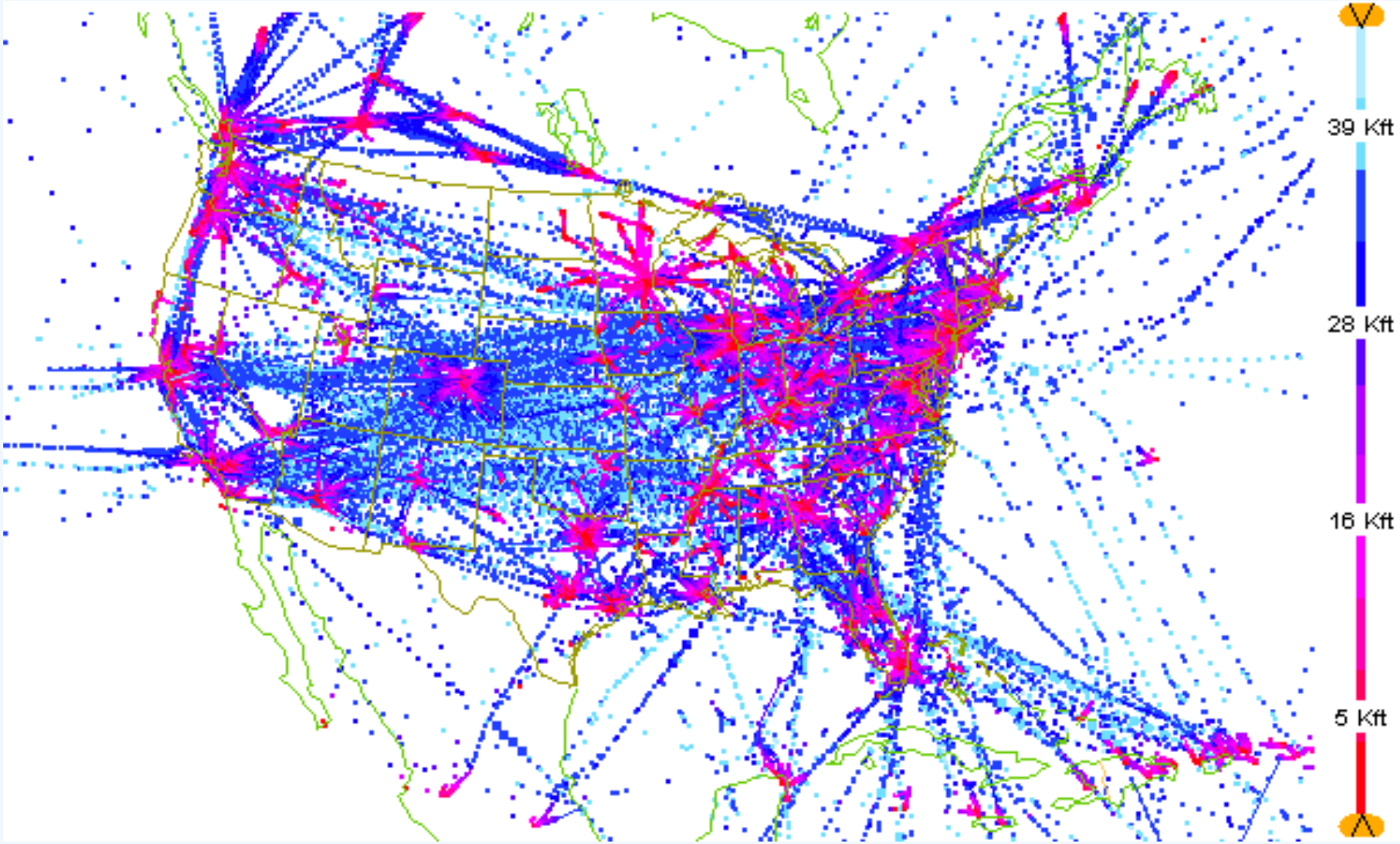
GPS-Met data are now ingested into NCEP operational NWP models

TAMDAR (a sensor operating on regional aircraft) data are now acquired by NWS and used as operational data by forecasters, and in NWP models

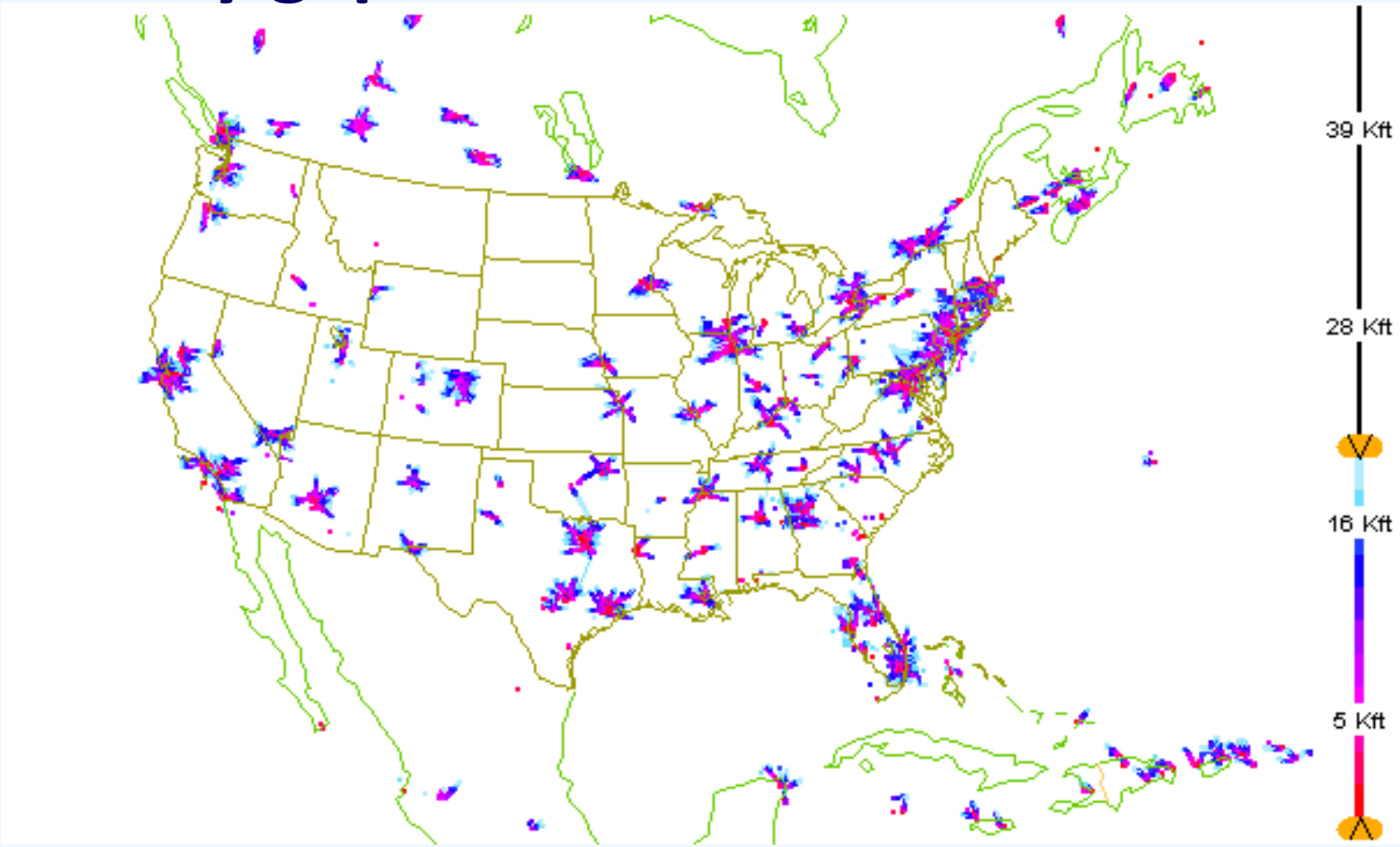
Example: TAMDAR

- TAMDAR is a new sensor system, designed to fill *gaps in mesoscale upper-air observations*
- These gaps have a **critical impact on short-term weather forecasts** relevant to aviation
- Our supercomputer capabilities allowed us to perform a
  - Three-year long parallel experiment with an operational model
  - That **documented TAMDAR's continuing positive impact on operational forecasts**
- Related to NOAA's mission to "To understand and predict changes in Earth's environment"
- Covered in more detail in Tracy Smith's poster

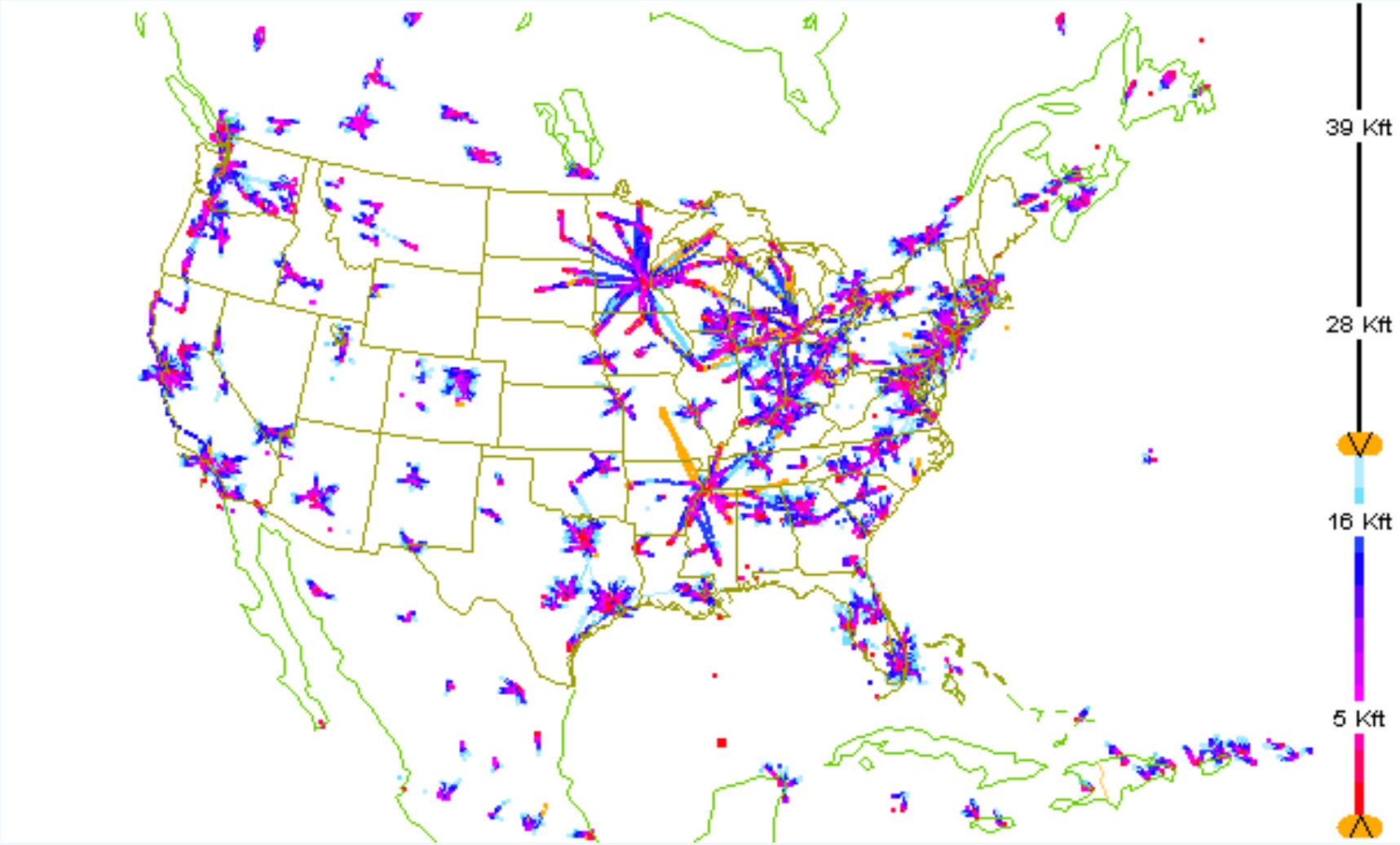
Aircraft data coverage over the CONUS looks dense…



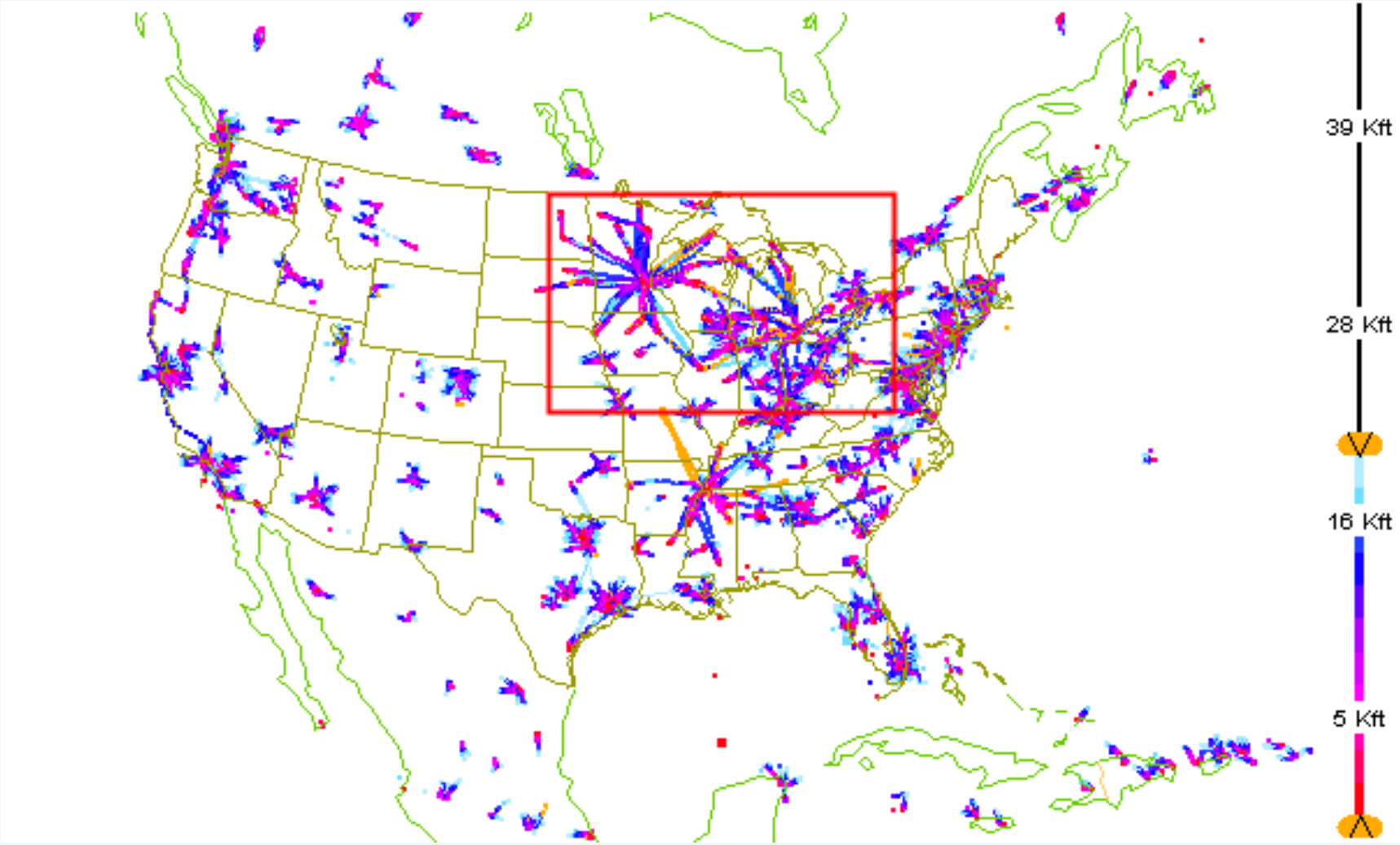
…but below 20,000 ft, there are many gaps



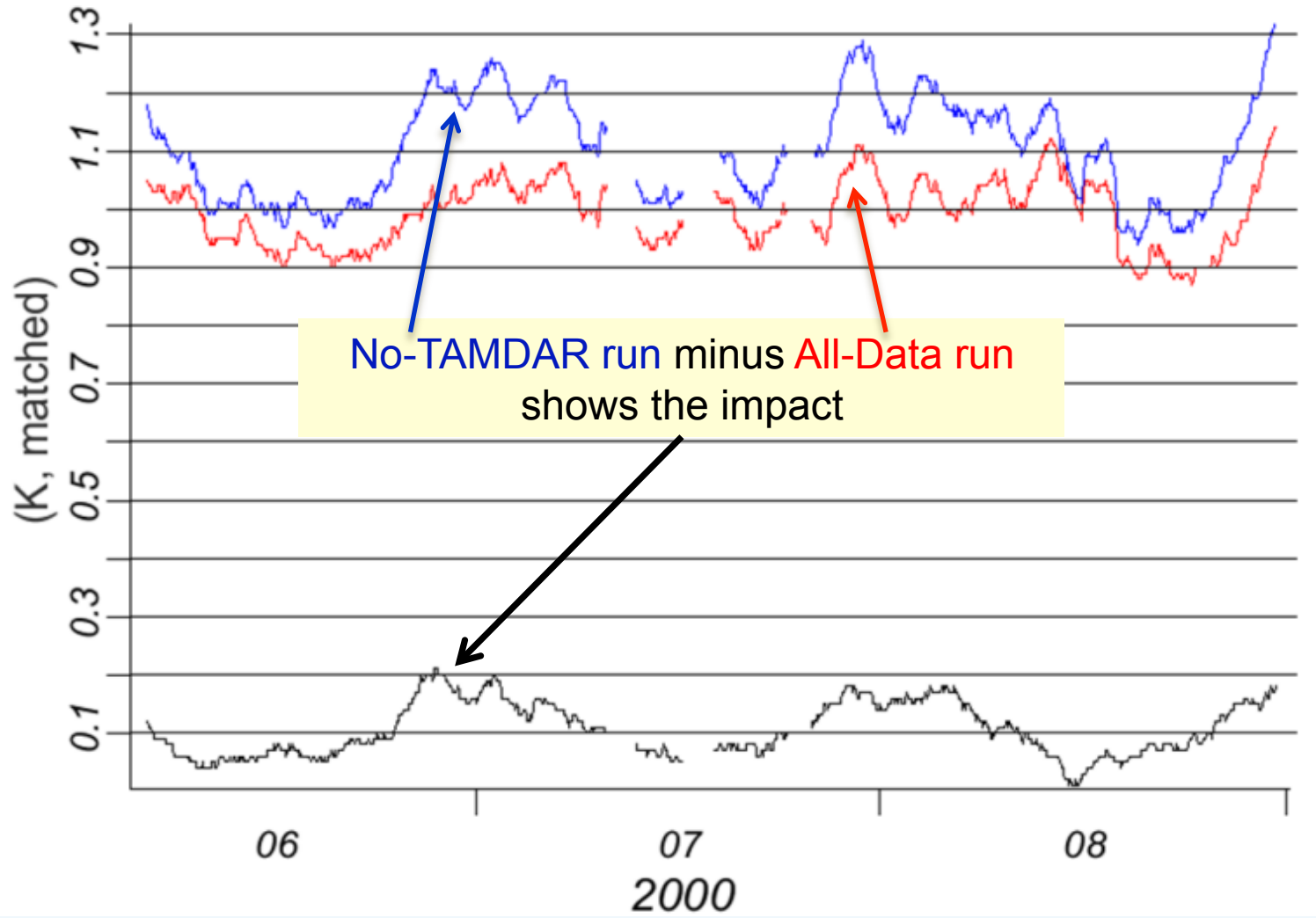
TAMDAR fills these gaps



We evaluated RUC model forecasts over the Great Lakes



Our results showed *substantial improvement in forecast skill due to TAMDAR*



3h forecasts
Great Lakes region
1000-400 hPa

(RMS difference between model and 0 UTC RAOBs)

TAMDAR Conclusions

- TAMDAR reduces NWP forecast errors
- For 3-h forecasts, *critical to aviation*,
  - Temperature errors reduced **up to 35%**
  - Relative Humidity errors reduced **up to 25%**
  - Wind errors reduced **up to 15%**
- **As a result**
  - NWS is purchasing TAMDAR data operationally
  - TAMDAR data are used in operational NWP models

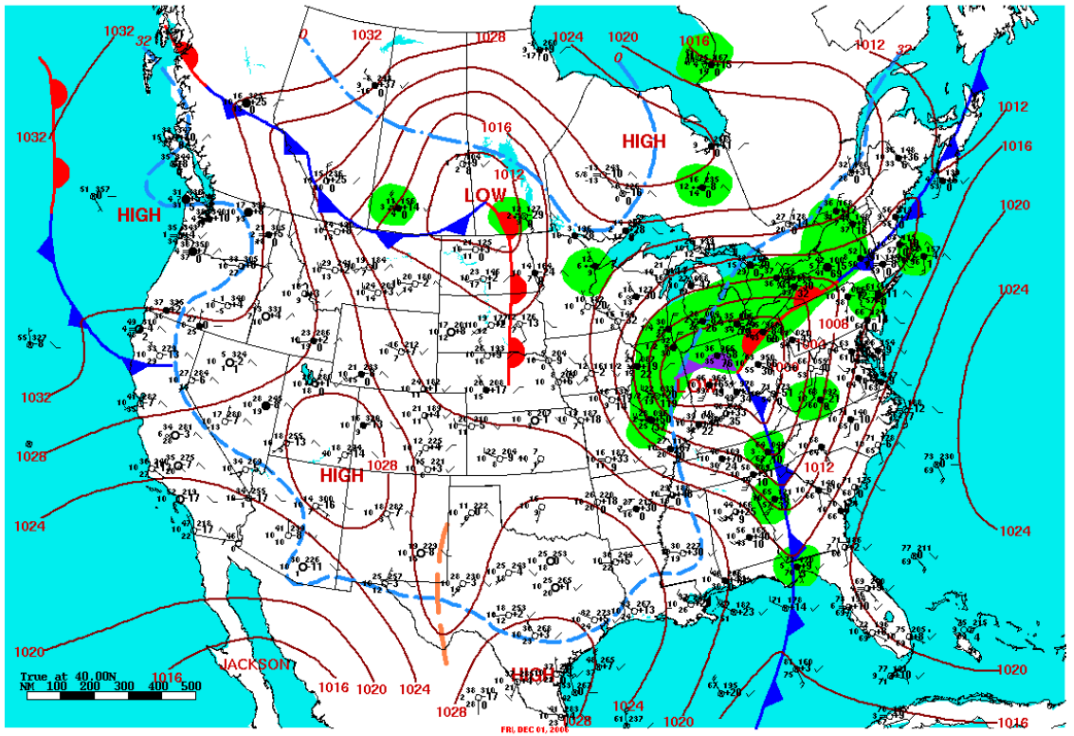
Example: *Relative* Impact OSE

- TAMDAR makes an impact, **but**…
- … NOAA must choose *among* data sets
- Which are most important for each kind of forecast?
- What is the most effective mix of observations?

Retrospective Runs

- **Winter**
  - 26 Nov - 5 Dec 2006
- **Summer**
  - 5-15 August 2007

- We ran over 50 data denial experiments over these periods



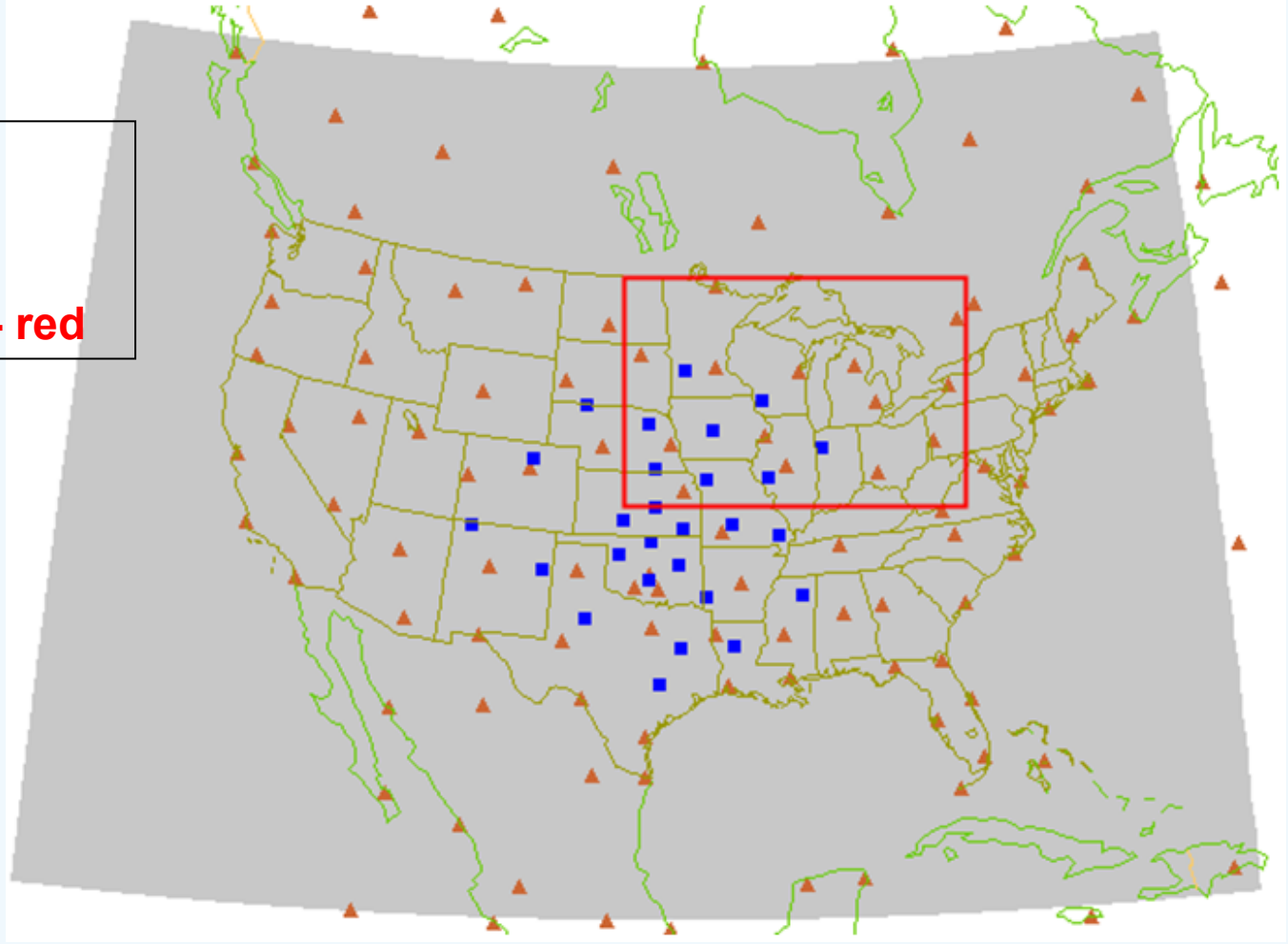
Surface analysis and data for 1200 UTC on 1 December 2006.

Forecasts were compared against RAOBs in several regions

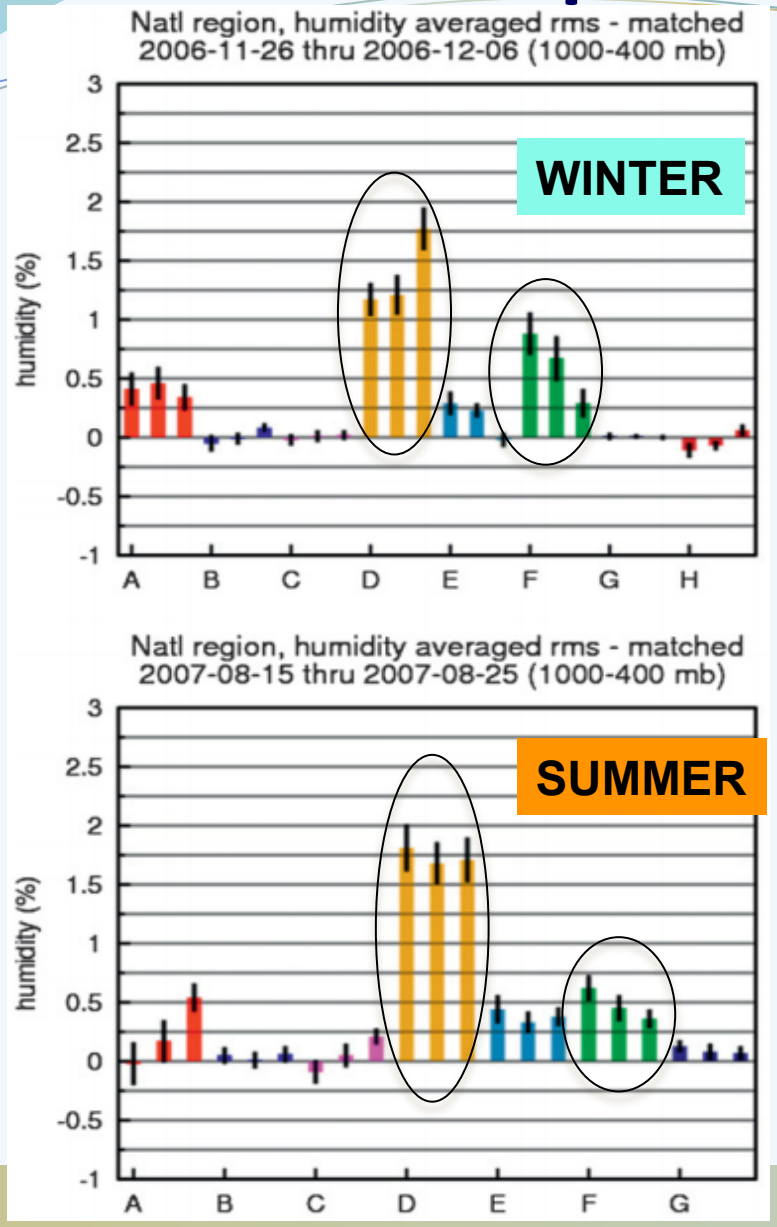
RAOBs – gold
Profilers – blue
RUC region – gray
Great Lakes region - red

Measure of forecast skill:

RMS difference with respect to RAOBs (RMSE)



Relative Impacts: 3-h, 6-h,12-h forecasts



Bar height: Difference between RMSE for data-denial run, and RMSE for all-data run

Black bar: Standard Error – shows statistical significance

RH - national – 1000-400 hPa

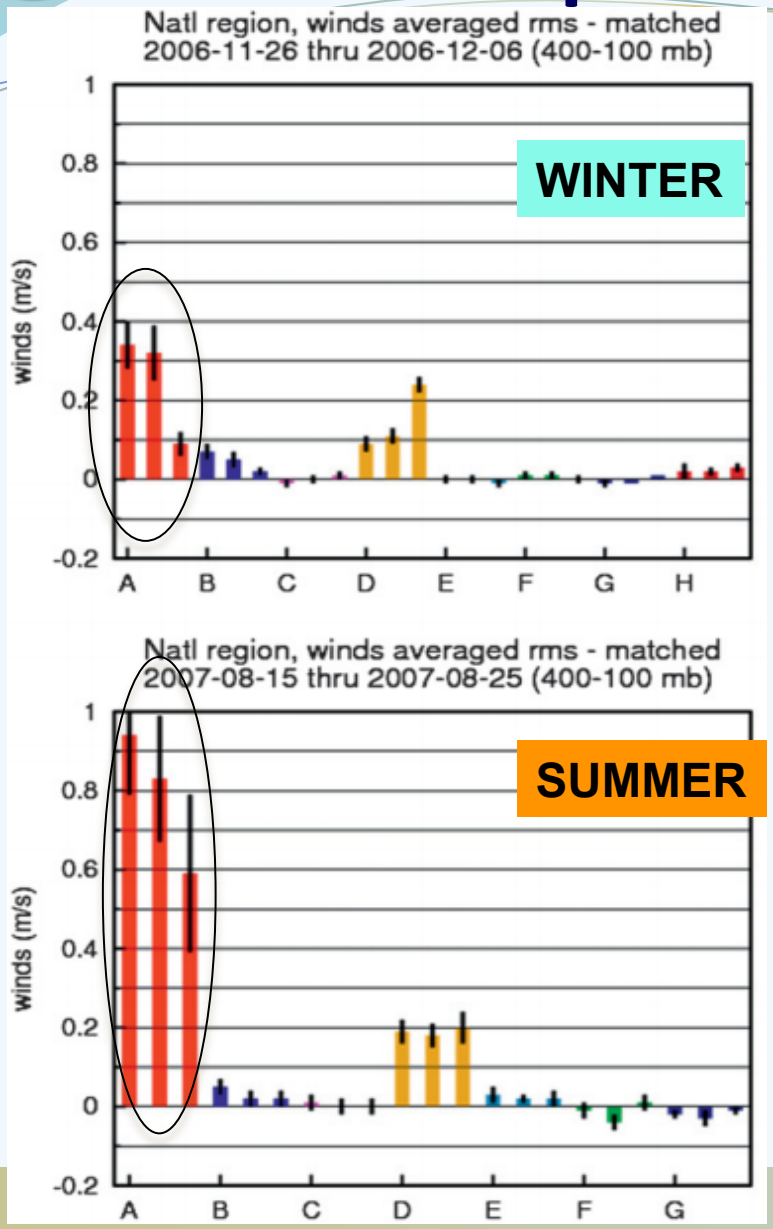
#1 obs type = RAOBs

#2 = GPS-MET

Aircraft	Surface
Profiler	GPS-MET
VAD	Mesonet
RAOB	Satellite

Different data sources are important in other circumstances

Relative Impacts: 3-h, 6-h,12-h forecasts



Bar height: Difference between RMSE for data-denial run, and RMSE for all-data run

Black bar: Standard Error – shows statistical significance

Winds - national – 400-100 hPa

#1 obs type = Aircraft

#2 = RAOBs

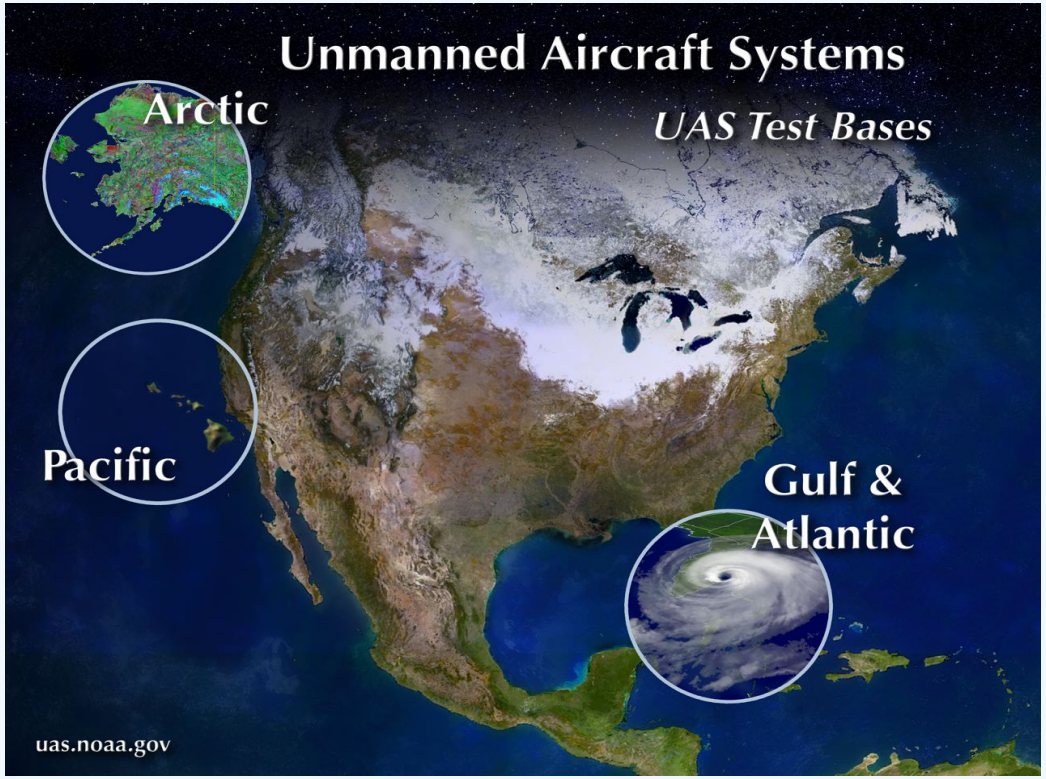
Aircraft	Surface
Profiler	GPS-MET
VAD	Mesonet
RAOB	Satellite

Results

- All data sets…
  - RAOB
  - Aircraft (including TAMDAR)
  - Satellite winds
  - Profiler
  - VAD
  - Surface
  - GPS-MET
- …add value for different kinds of short-term (3-12-h) forecasts
- NWS *operational procurement decisions* are critically informed by these experiments
- MWR article (in press, Apr-June 2010, Benjamin et al.) presents detailed results; Companion paper to Moninger et al. (2010 WAF) on TAMDAR impact results.

Other examples we'll cover today: Unmanned aircraft systems (UAS)

- Fill spatial gaps
  - Geographic gaps (e.g., over the ocean)
  - Vertical gaps (between satellites and surface)
- As recognized in NOAA's Technology and Mission Support Goal:

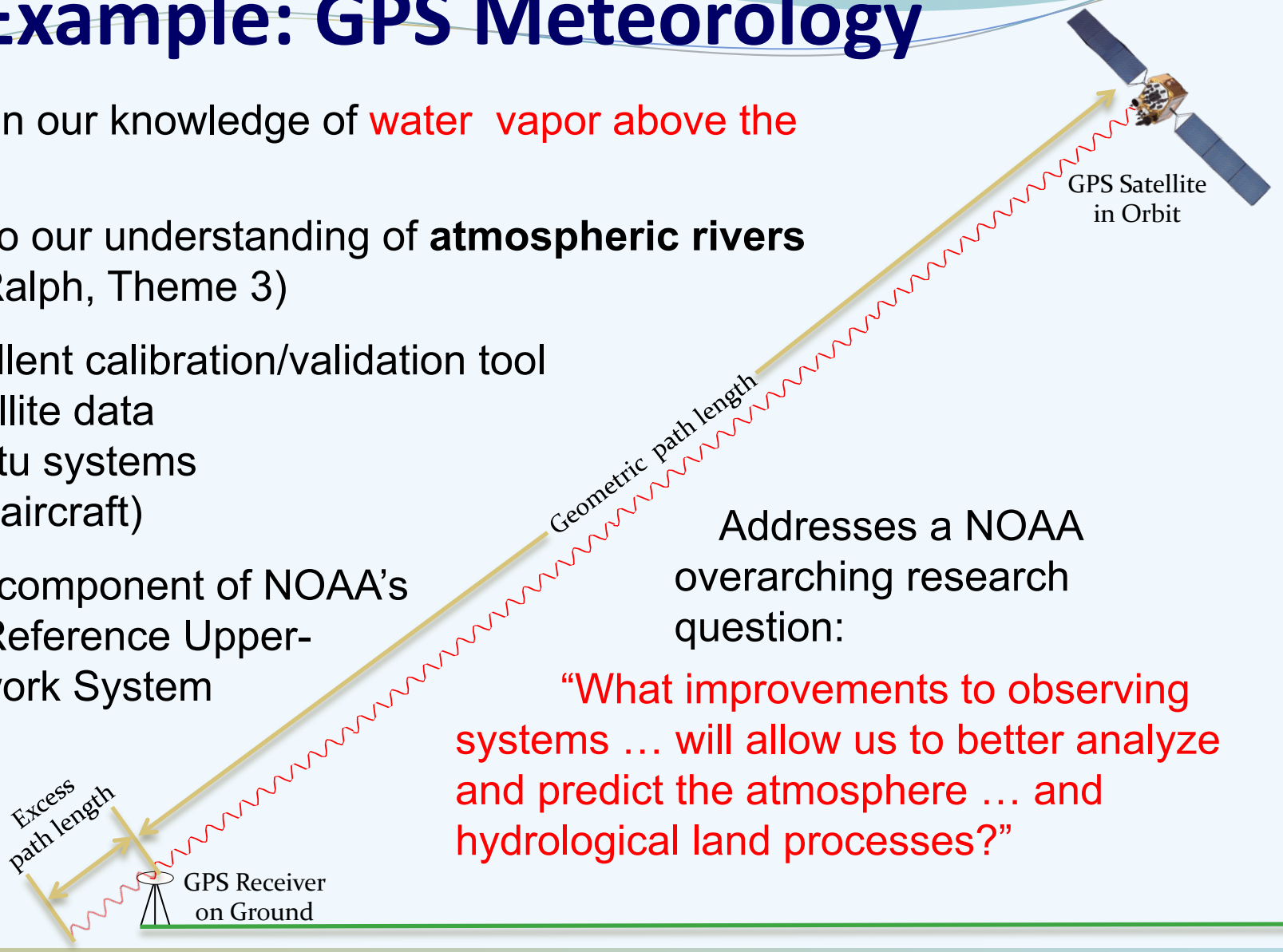


"UAS technology is necessary to sample environments that are either impossible or impractical to observe ..."

Example: GPS Meteorology

Fills a gap in our knowledge of water vapor above the surface

- Critical to our understanding of **atmospheric rivers** (Marty Ralph, Theme 3)
- An excellent calibration/validation tool
- For satellite data
- For in-situ systems (RAOB, aircraft)
- Integral component of NOAA's Global Reference Upper-Air Network System



Addresses a NOAA overarching research question:

"What improvements to observing systems … will allow us to better analyze and predict the atmosphere … and hydrological land processes?"

Other Work (covered in posters)

- WISDOM: balloon borne sensors designed to fill data gaps near tropical cyclones
- OSSEs: Simulation experiments to test the potential impact of UAV's, and develop an infrastructure for future OSSEs. Fills a gap in our knowledge of data system impact
- Field experiments: that provide quasi-operational performance tests of research data systems. Fill the research-to-operations gap, and fill gaps in our meteorological understanding

Other Work (covered in posters)

- MADIS: a data fusion/QC/distribution system that fills the gap in providing timely, accurate data to those who need it
- Inuit weather/climate study: using observations from indigenous peoples to inform us about weather and climate changes – fills a gap in our storehouse of methods for gathering critical current and past *in-situ* information

Summary and the Way Forward

- John Brown will provide these at the end of this session
- Questions on this introduction?